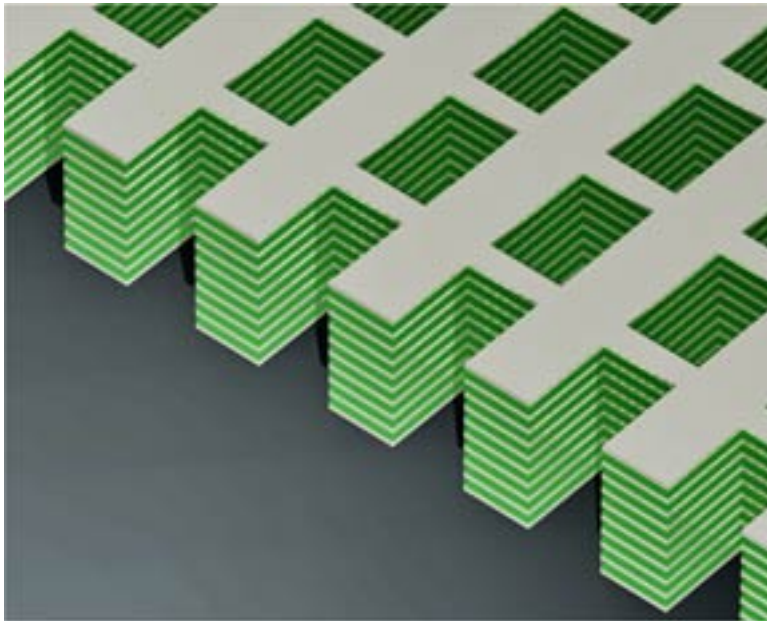
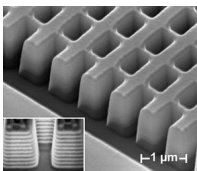


Scientists at the University of California, Berkeley, have for the first time engineered 3-D materials that can reverse the natural direction of visible and near-infrared light, a development that could help form the basis for higher resolution optical imaging, nanocircuits for high-powered computers, and, to the delight of science-fiction and fantasy buffs, cloaking devices that could render objects invisible to the human eye.

Two breakthroughs in the development of metamaterials - composite materials with extraordinary capabilities to bend electromagnetic waves - are reported separately this week in the Aug. 13 advanced online issue of **Nature**, and in the Aug. 15 issue of **Science**.



Above is a schematic of the first 3-D "fish-eye" metamaterial that can achieve a negative index of refraction (the first 3-D "fish-eye" metamaterial).



Applications for a metamaterial entail altering how light normally behaves. In the case of invisibility cloaks or shields, the material would need to curve light waves completely around the object like a river flowing around a rock. For optical microscopes to discern individual, living viruses or DNA molecules, the resolution of the microscope must be smaller than the wavelength of light.

The common thread in such metamaterials is negative refraction. In contrast, all materials found in nature have a positive refractive index, a measure of how much electromagnetic waves are bent when moving from one medium to another.

Other research teams have previously developed metamaterials that function at optical

frequencies, but those 2-D materials have been limited to a single monolayer of artificial atoms whose light-bending properties cannot be defined. Thicker, 3-D metamaterials with negative refraction have only been reported at longer microwave wavelengths.

"What we have done is take two very different approaches to the challenge of creating bulk metamaterials that can exhibit negative refraction in optical frequencies," said Xiang Zhang, professor at UC Berkeley's Nanoscale Science and Engineering Center, funded by the National Science Foundation (NSF), and head of the research teams that developed the two new metamaterials. "Both bring us a major step closer to the development of practical applications for metamaterials."

Zhang is also a faculty scientist in the Material Sciences Division at the Lawrence Berkeley National Laboratory.

Transmission measurements of these structures were carried out by the Zhang group at ALS beamline 1.4.3.

See the [full news release from UC Berkeley](#) .

Other news stories about this work: August 11: [ScienceNow](#) ; [USA Today](#) ; [ABC News](#) ; [Associated Press Video](#)

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[National Geographic](#)

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[NPR Radio](#)

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[The New York Times](#)

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[CNN](#)

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[Reuters](#)

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[BBC News](#)

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[SF Chronicle](#)

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[London Times](#)

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